

SOLUTION MINING RESEARCH INSTITUTE

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MEETING
PAPER



THREAT OF A SINKHOLE: A REEVALUATION OF
CAVERN 4, BAYOU CHOCTAW SALT DOME, LOUISIANA

by

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ABSTRACT

Cavern Lake at Bayou Choctaw salt dome resulted from the failure of Cavern 7 in 1954. Uncontrolled solutioning of this cavern through the thin **caprock** had set the stage for overburden to collapse into the cavern below. A similar situation developed with nearby Cavern 4, but with less dissolution of the **caprock**. Because pressure loss was already a problem and because another 800 ft diameter lake would have endangered surface operations, solutioning of Cavern 4 was stopped and the cavern abandoned in 1957 in order to protect the already-small site. In 1978 the Strategic Petroleum Reserve (SPR) acquired a number of caverns at Bayou Choctaw, including Cavern 4, and the possible repeat of the Cavern 7 failure and formation of another lake thus became an issue. The cavern dimensions were re-sonared in 1980 for comparison with 1963 and 1977 surveys. Annual surface leveling between 1982-92 showed less subsidence occurring than the site average, and a cavern monitoring system, installed in 1984, has revealed no anomalous motion. Repeat sonar surveys in 1992 showed very little, if any, change occurred since 1980 although a small amount of uncertainty exists as a result of changing sonar techniques. We conclude that significant additional solutioning or erosion of the **caprock** has not occurred and that there is no increased threat to SPR operations.

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Introduction:

In the history of solution mining, relatively few caverns in domal salt have failed completely, and perhaps only one as dramatically as Cavern 7 at Bayou Choctaw in January, 1954. In those early days before sonar and highly controlled brining, Cavern 7 had no salt roof and was leached completely through the **caprock**, allowing the overburden to collapse directly into the cavern. [Figure 1] It didn't take more than about a day and an 800 ft diameter sinkhole formed, now filled with water and known as Cavern Lake. [Figure 2; aerial view of Bayou Choctaw dome and Cavern Lake].

Storage operations at Bayou Choctaw have continued to the present; the Strategic Petroleum Reserve (SPR) became a tenant in 1978, **co-**located with its neighbor Allied, now Union Texas Petroleum, which stores LPG, natural gas, and extracts brine. But the memory of the Cavern 7 event has not been forgotten and it reminds us nearly 40 years later that things can and do happen!

This paper is about Cavern 4, now abandoned but not far from Cavern 7, and with some similar conditions. We review its status and comment on future actions that may assure continued safe operation of adjacent caverns and facilities.

Cavern 4 Geometry and Similarity with Cavern 7

Cavern 4 has no salt roof, having been brined without blanket as in the case of Cavern 7. As with Cavern 7, erosion into the **caprock** also had occurred and it was abandoned in 1957, after the 1954 collapse of Cavern 7 [Figure 3]. Because of similarities in the geology and cavern size, the 1980 geological characterization report [Acres, 1980] concluded that a similar collapse could occur over Cavern 4, resulting in an 800 ft diameter lake and affecting some of the non-critical SPR facilities, such as the brine pond [Figures 4 and 5]. Because of this potential, several site and system changes were introduced, and a collapse warning system was engineered and installed [Todd and Smith, 1988].

NORTH

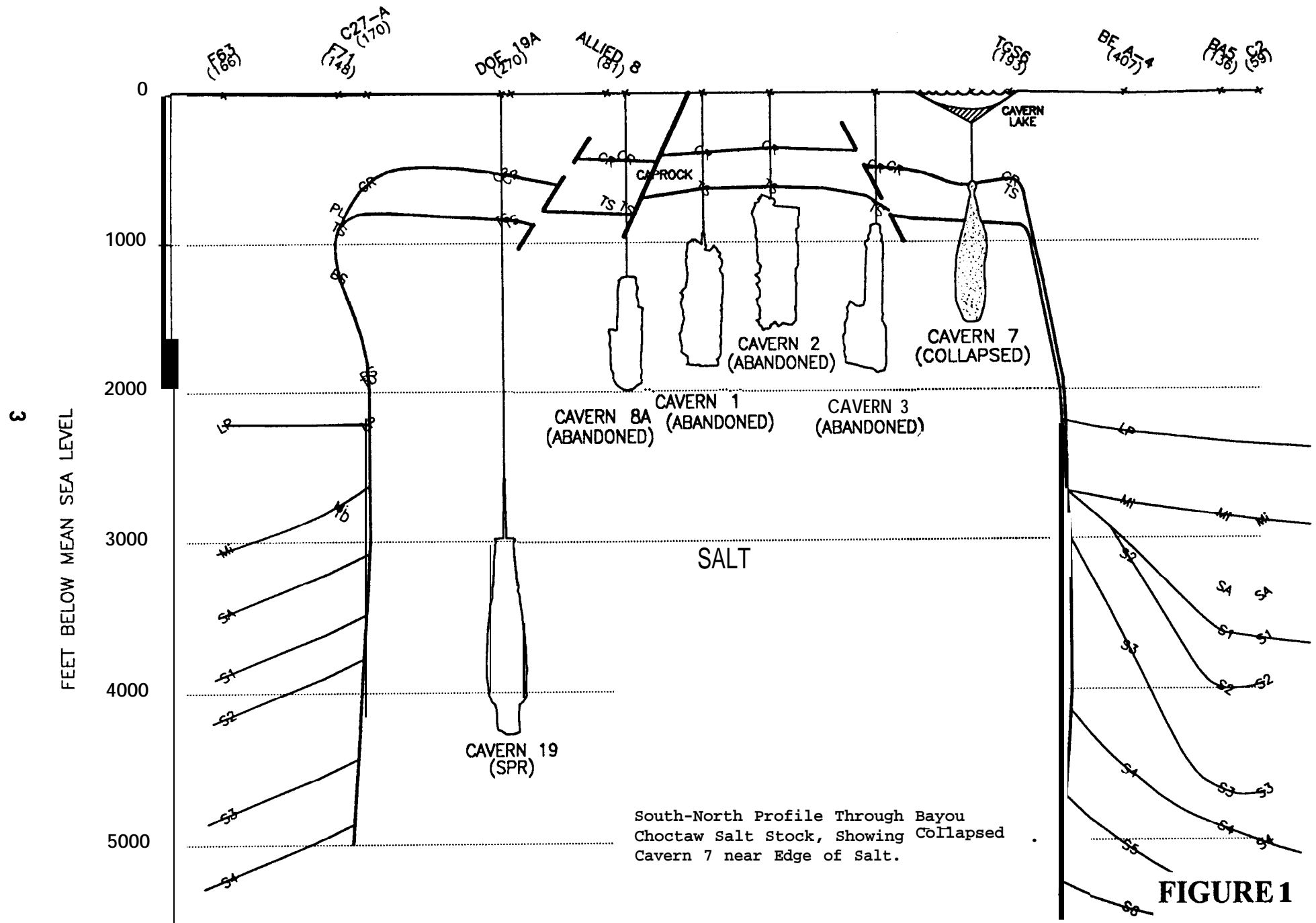
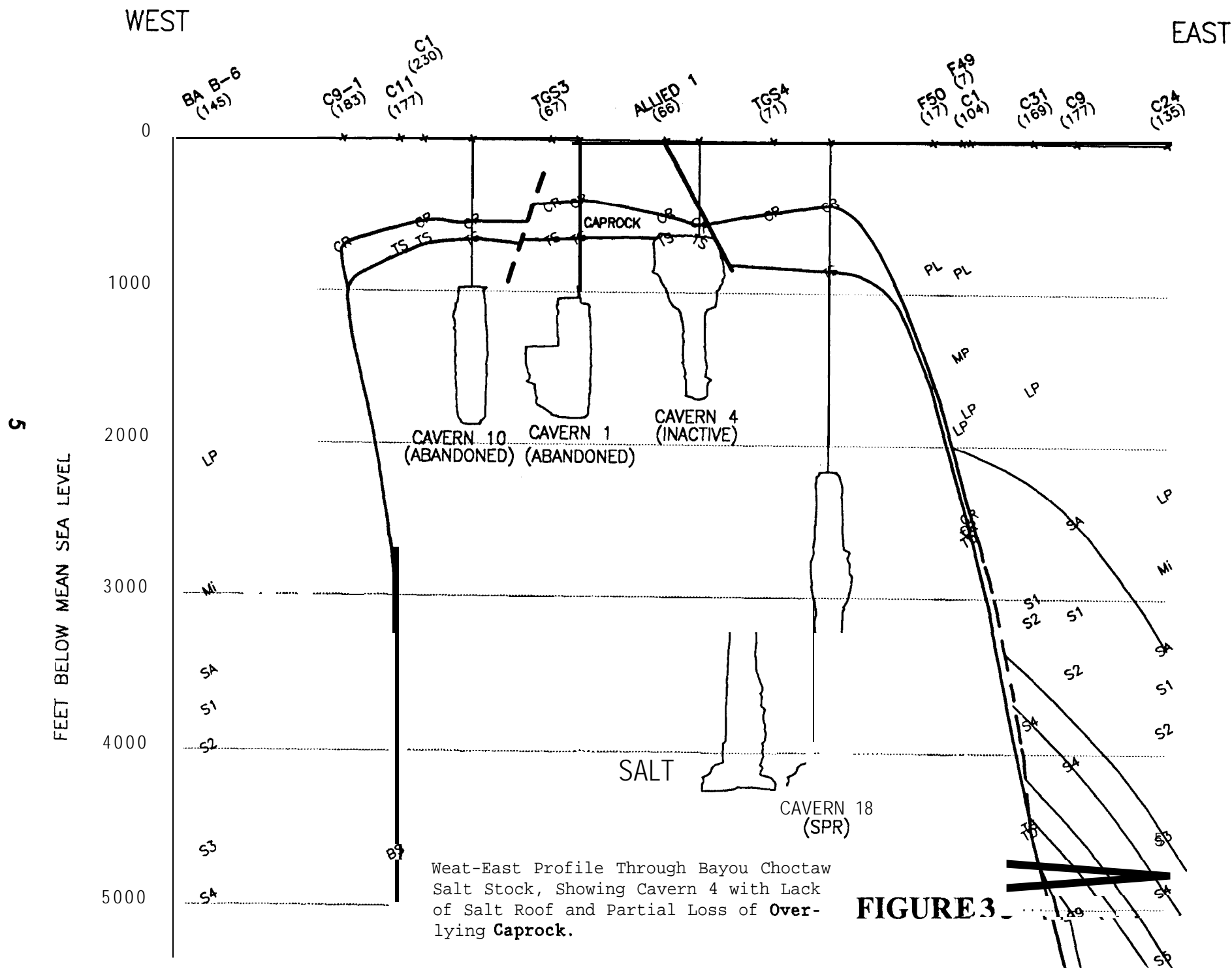


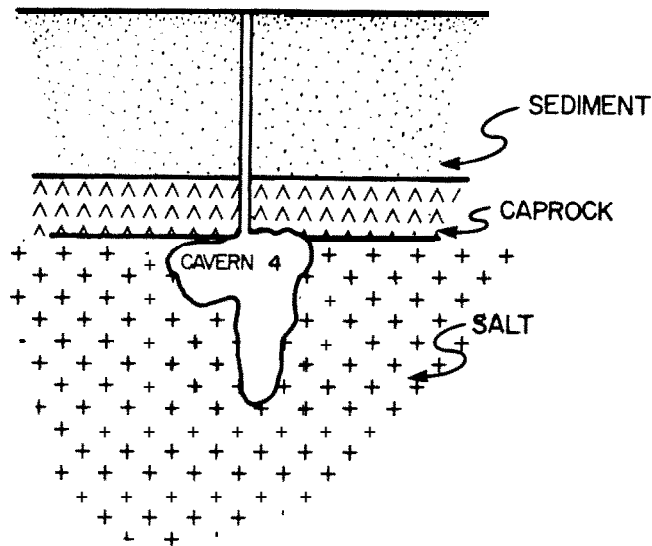
FIGURE 1



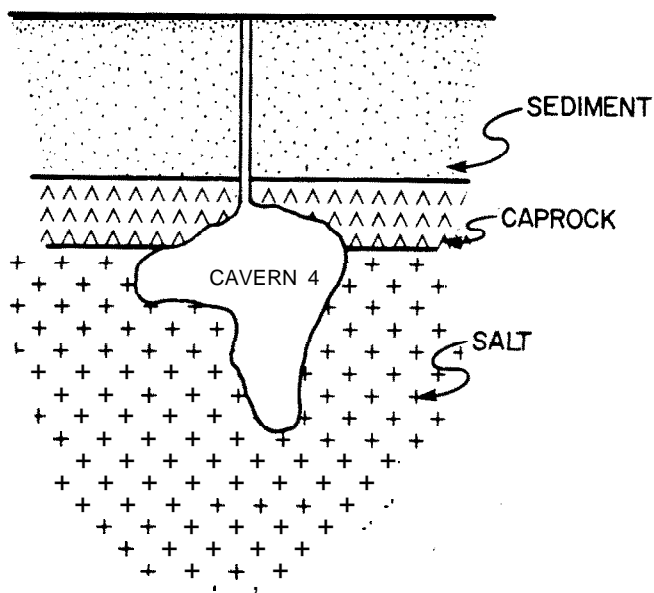
FIGURE 2 Aerial view of Bayou Choctaw salt dome, showing Cavern Lake at left and Cavern 4 at center (arrow) of photo.



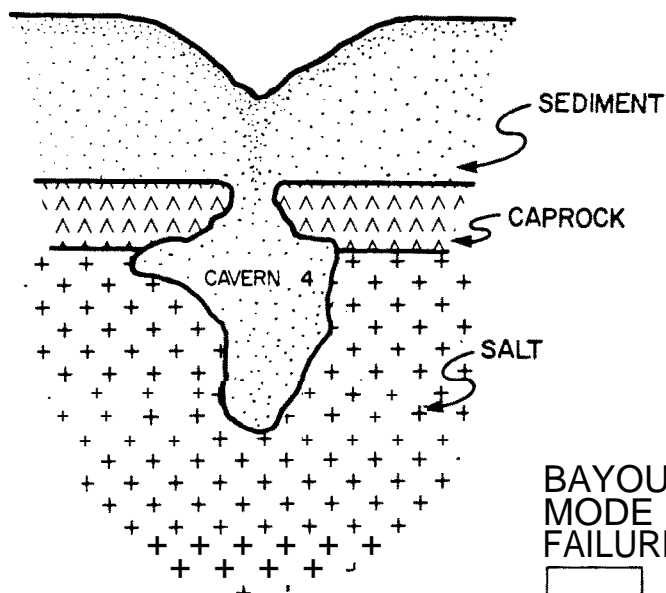
(A)



(B)



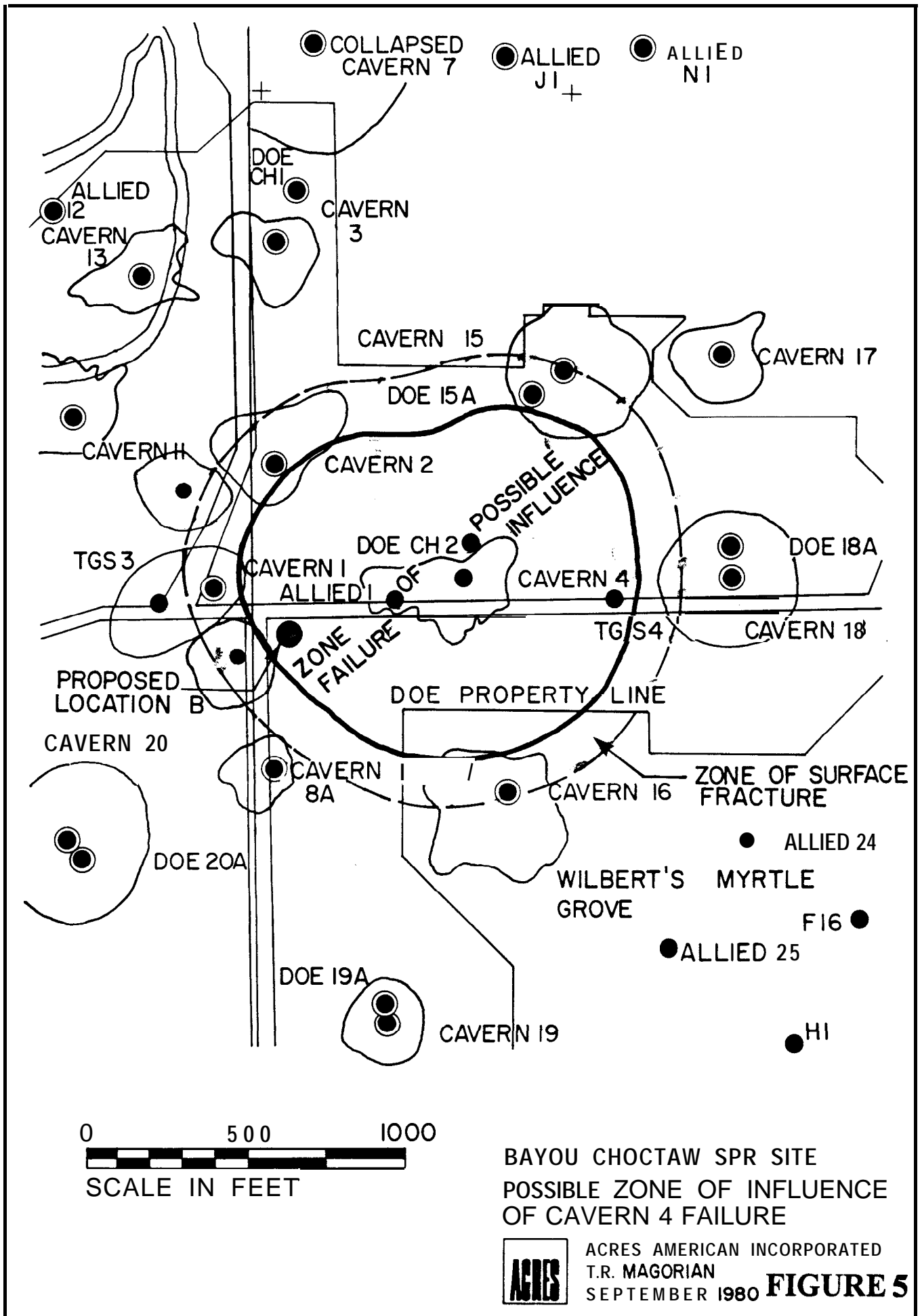
(C)



BAYOU CHOCTAW SPR SITE
MODE OF POSSIBLE CAVERN 4
FAILURE



ACRES AMERICAN INCORPORATED
T.R. MAGORIAN
SEPTEMBER 1980 **FIGURE 4**

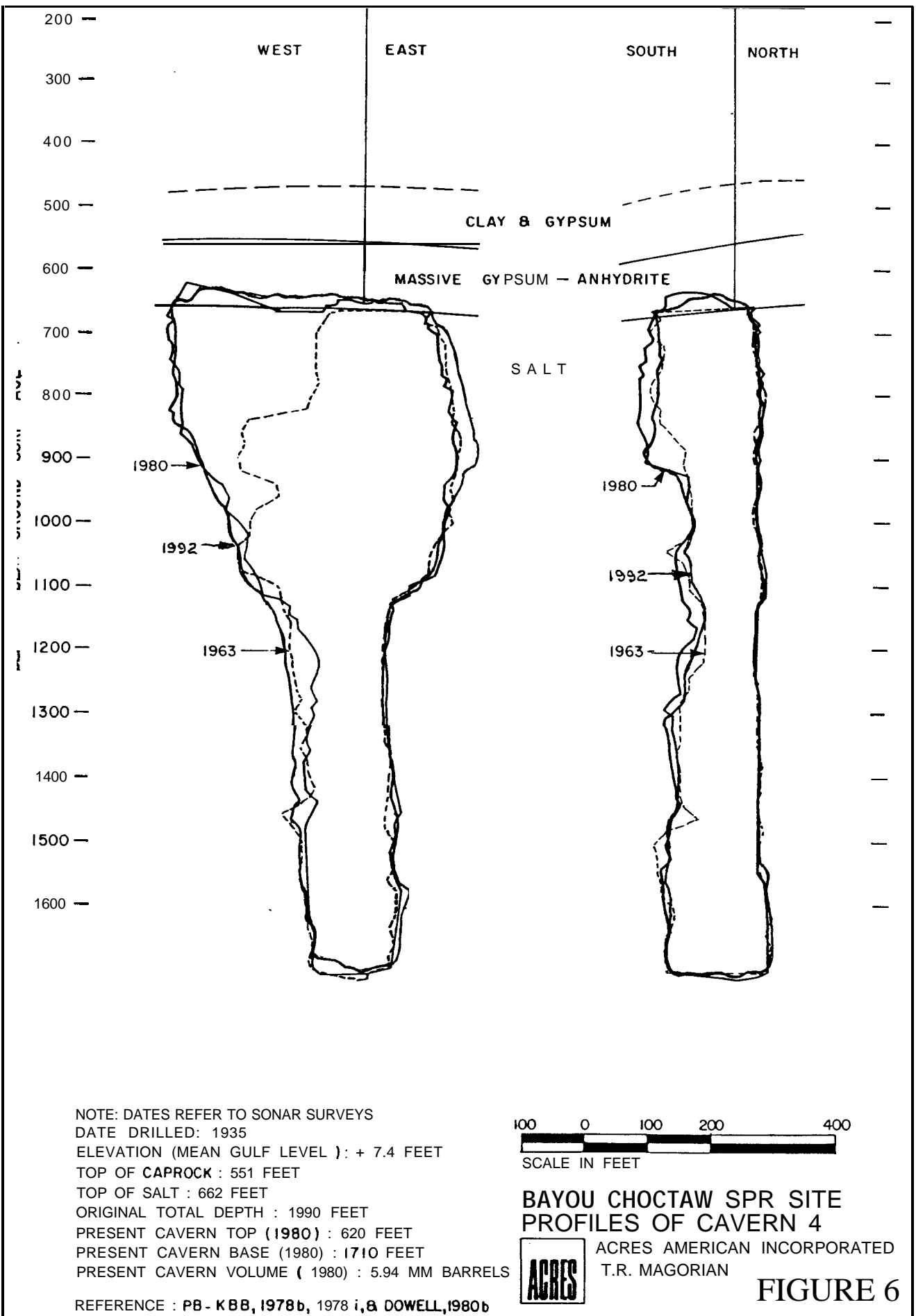


Cavern 4 Status and History

Some 12 years of safe SPR operations have taken place, and although there have been no hints of instability or abnormal subsidence over or near Cavern 4, substantial uncertainty remains regarding the geometry of the cavern roof area, especially the amount of additional **caprock** removal by leaching or rockfall. PB-KBB, in its 1978 analysis of the situation, suggested it was reasonable to assume that communication was occurring in the lost circulation zone at the **caprock/salt** interface and that it would continue to promote removal of **caprock** over the cavern roof. This prediction was based in part on the measured enlargement of the caprock/roof area between 1963 and 1978, as determined from sonar measurements [Figure 6]. Between the 1977 and 1980 surveys, there appeared to have been no further change of significance [Todd and Smith, 1988]. The 1977 volume estimate from sonar was about 5.85 MMB, but 1980 sonar volume measurements indicated 5.94 MMB, an increase of about 1.5 % -- which could represent further dissolutioning, or more likely be within the error range of the survey. Estimates from production records suggested the volume should have been approximately 14.8 MMB, a major inconsistency [PB-KBB, 1978]. PB-KBB suggested that salt solutioning not observable on sonar might be responsible for the disparity. Mills [1993] notes the plan view cross sections in the 1992 sonar report are extremely irregular and support the notion of hidden volume. The shape also makes radius and volume interpretations more difficult and variable.

Contributing Factors: Anomalous Zones

Even though there is little new information at Bayou Choctaw, there is increased understanding of anomalous zones in salt domes in general [Kupfer, 1980, 1990; Thorns and Neal, 1992]. The 1980 report identified a major fault zone (F2), possibly active, that intersects the dome in the vicinity of Cavern 4. Our newly revised **caprock** and salt maps [Magorian, 1993] clearly show the subsurface expression of this fault as it traverses the top of the dome. It is likely that this external fault is manifested as a shear zone in the salt stock, and is probably a boundary between two discrete spines of salt. Such conditions could account for the pronounced west-extending wing that appears in the sonar profiles [Figs. 6 and 7]. Cavern 1, 800 ft west of Cavern 4, also has a westerly-extending wing paralleling the trend of the fault zone, possibly further substantiating the notion that an anomalous zone exists in that vicinity.



The revised **caprock** and salt maps map in the recently updated geologic site characterization report [Figs. 7 and 8; ref. Neal and Magorian, 1993] shows this fault transecting the entire dome and which passes directly through Cavern 4, and which is directly in line with the elongation axis of the cavern. This correlation is apparently more than coincidental, and suggests that the enlargement potential of Cavern 4 could be influenced by the nature of materials along this fault.

August 1992 Re-sonar

To resolve some of these questions, a re-sonar of Cavern 4 was conducted in August 1992 to determine what changes might have occurred in the **caprock** since 1980. The survey showed that no major change has **occured** in the comparative appearance of sonar profile graphics [Fig. 6] although there is some evidence of a roof fall about 150 ft west of the wellbore. The overall 6% enlargement in volumetric calculations from 1980 may indicate some additional solutioning in the cavern, although much of the 6% can be attributed to the expected survey inaccuracies and allowable error. Another factor to consider is that cavern creep closure should have reduced cavern volume by about 1% over the 12 yr period between surveys. About one-third (150,000 bbl) of the reported 6% increase from 1980 is at or above the -600 ft level. Slezak [personal communication, 1992] cautions that the two surveys are not comparable in that different tools were used; the 1980 survey employed only horizontal look angles, and the volume at the top of the cavern above the casing at -648 ft is not included in the reported cavern volume, even though the horizontal accuracy was more precise. Todd [1993] considered the evidence and concluded there is no basis to believe that significant change occurred between 1980 and 1992 [Fig. 9].

Conclusions

Thus a degree of uncertainty remains, and shows that a small amount of **caprock** dissolutioning *may* have occurred during the **preceeding** 12 years. If change could be proved to have occurred, possible stabilization measures might be considered and mitigation instituted. But little additional action seems justifiable at this time in view of the facts as are known. The injection of grout into the remaining overlying **caprock** and overburden roof is one course of action

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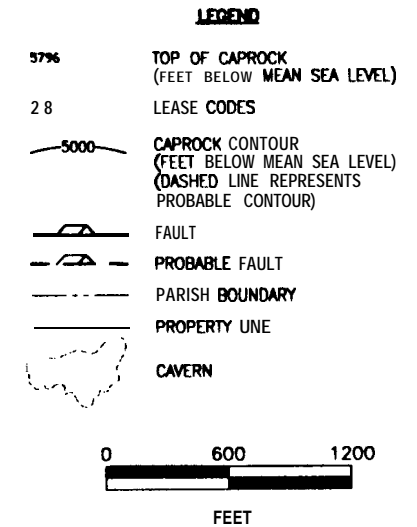
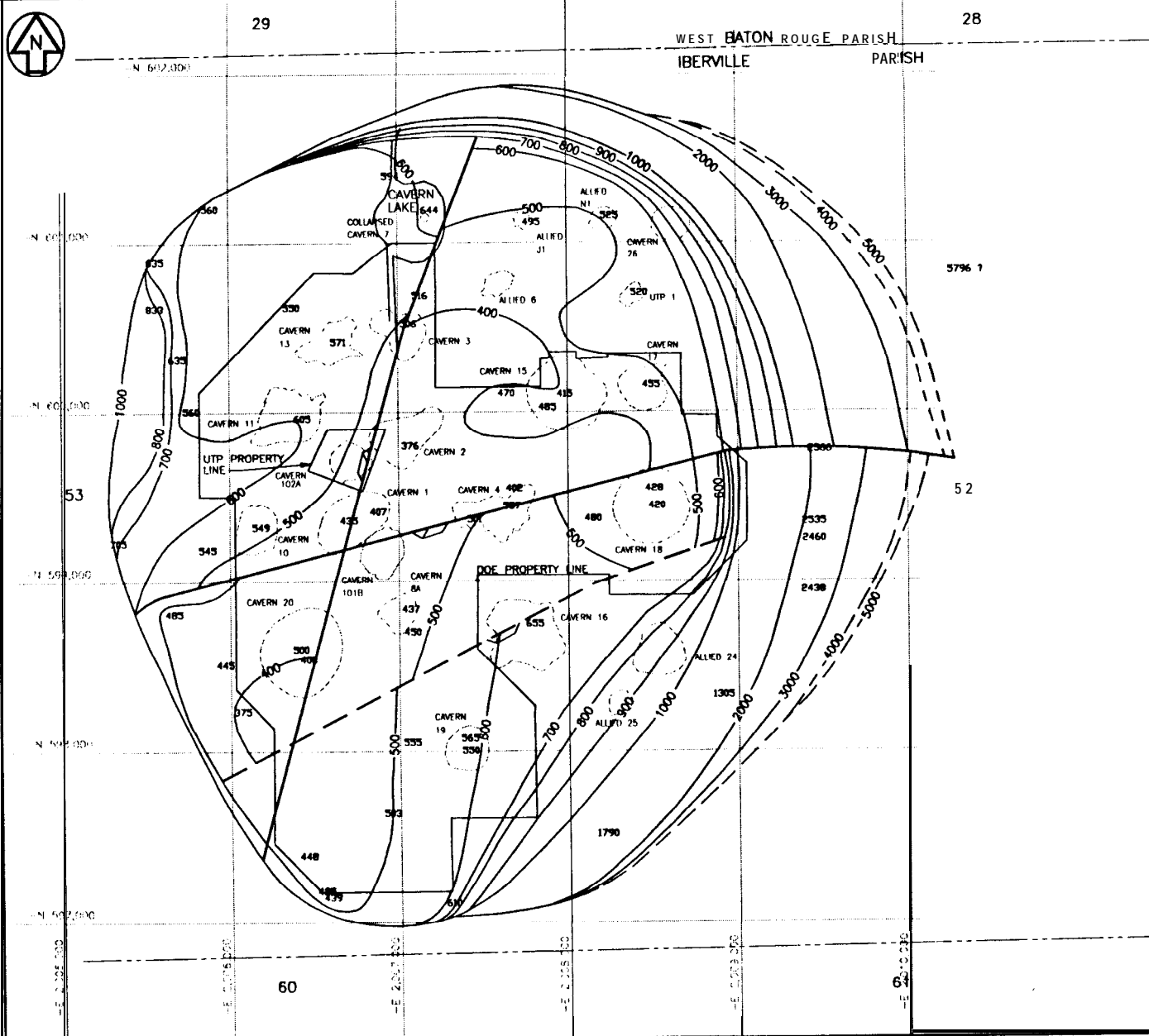
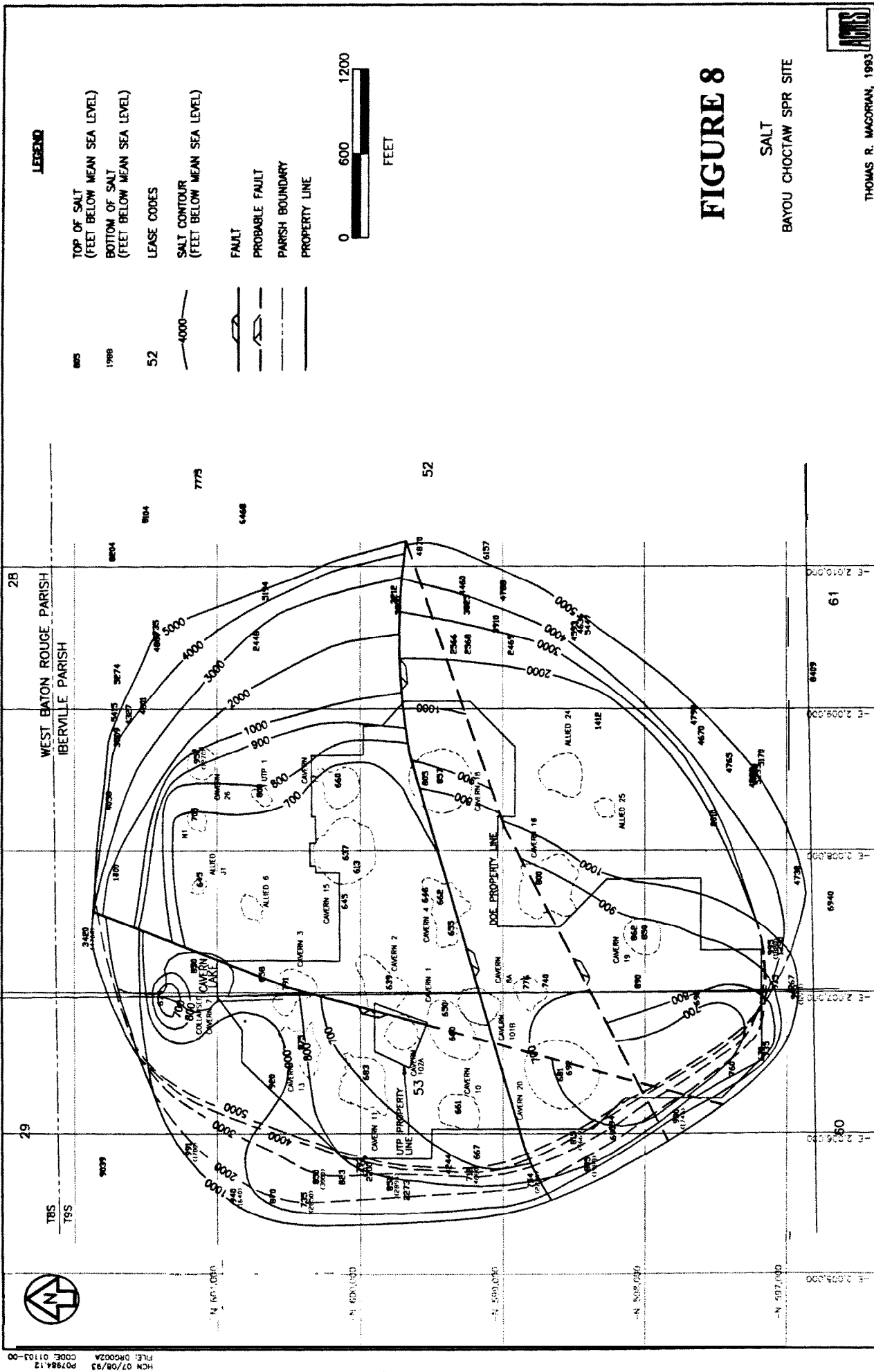
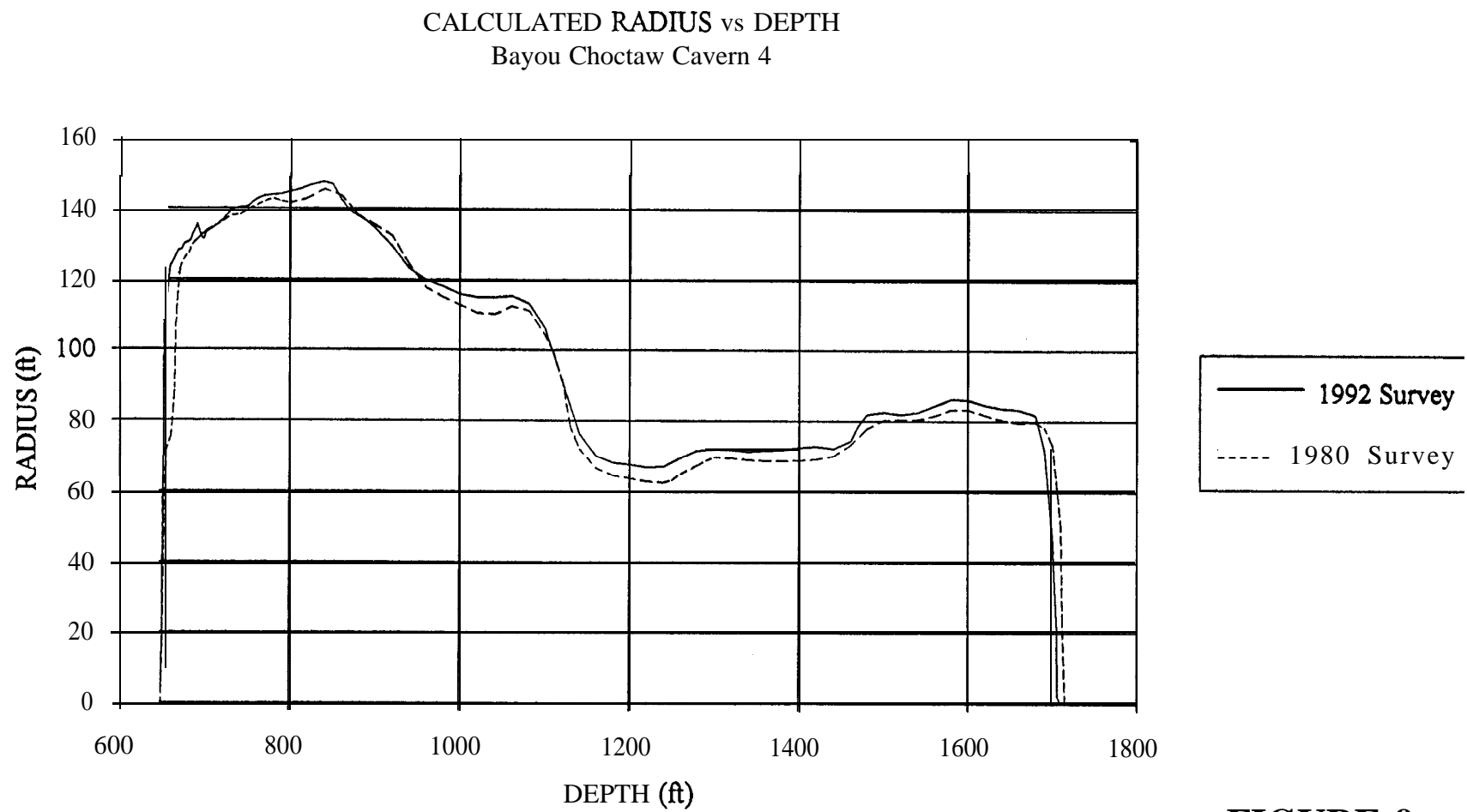


FIGURE 7

CAPROCK
 BAYOU CHOCTAW SPR SITE





**FIGURE 9**

that might be considered at a future date, but this may be impractical. The authors of this report believe a re-sonar of the cavern would be prudent in about five years and provide a rational basis for planning.

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